TPC alignment summary

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- Revision of TPC hit errors and systematics (the systematics in coordinate measurement is a part of alignment):
  - Revision of cluster errors based on simulation has been done based on TpcRS simulation:
    - Observed significant systematics (dT ~ 0.2 timebuckets, dZ ~ 0.1 cm, comparable with our errors in Z), especially for fixed target data due to significant extend of kinematics.
    - Simple 2D error parameterization (Z and tan(ψ), Z and tan(λ)) does not work.
    - See details https://drupal.star.bnl.gov/STAR/system/files/Revision%20Tpc%20sytematics%20and%20errors_1.pdf
  - It was made a 4D parameterizion (tan(ψ), tan(λ), Z, and log(ADC)) for both systematics and error.
  - This revised model for systematics has been used in the alignment procedure.
- TPC Alignment:
  1. Reasons: Significant degradation of Y width with respect to expected one, observed before iTPC era (160 MeV => 240 MeV), …
  2. Implementation: Use survey of iTPC pad (freeze inner sector) and align outer sectors to inner ones (opposite to what was done in 2019, when we relayed on old (2013) TPC alignment for outer sectors).
  3. Account gravitational distortion of TPC cylinder by introducing sector dependent direction of electric field.
  4. Alignment procedure has bee applied for all Cosmics data with iTPC (2019-2024) for both magnetic fields.
  5. See results https://drupal.star.bnl.gov/STAR/system/files/Tpc%20Alignment%202024%20overview.pdf:

  Observed significant improvements (K^0_s width is reduced by ~15%,K^0_s signal to background ration is increase by ~50%, …)
- Impact on reconstruction:
  - It was observed that the production with new alignment requires a factor of ~1.5 more cpu than old one.
  - The reason is that Sti requires a factor of 2 more time for track reconstruction.
  - The factor of 2 in the reconstruction is coming from two reasons:
    1. More hits are rejected during the fit with new hit errors, and this rejection requires another iteration(s) to refit track.
    2. The track fit convergence is defined by a requirement that the maximum deviation of any track parameters after the fit has to be $(\Delta p/\sigma)^2 < 0.01$. This happens a factor of 2 more times with new hit errors than with old ones.
  - These observations have to be addressed. I see three possible ways:
    1. To optimize hit rejection and convergence criteria. This requires significant efforts.
    2. Keep old hit errors for collider data and use new systematics as a backup solution. This requires validation.
    3. Do nothing, i.e. use old alignment for collider data (if you don't care about results quality).

One more possibility

- To use a “default” reconstruction to select a sample of the interest (High Level Trigger 5): Candidates for events with Y, W, hyper nuclear, charm, … with reduction factor ~1000.
- Process this sample with an “advance reconstruction”, which can provide visible improvement in the reconstruction quality. For example:
  - Track fit with mass hypotheses,
  - State of art alignment, and
  - Any other adjustments which require access to hit level data.
- This approach assumes much more complicated logistics.
- But for some physics tasks, where the reduction factor of ~1000 and significant reconstruction improvements could be achieved, this is worthwhile approach.